SIEPR Conference on FCC Incentive Auction

Interference and Repacking Issues

February 26, 2013

Agenda

- *Part 1: Broadcast Service 101*
- *Part 2: Repacking Models – Past & Present*
- *Part 3: Incentive Auction and the FCC Process*
- *Part 4: Final Thoughts*

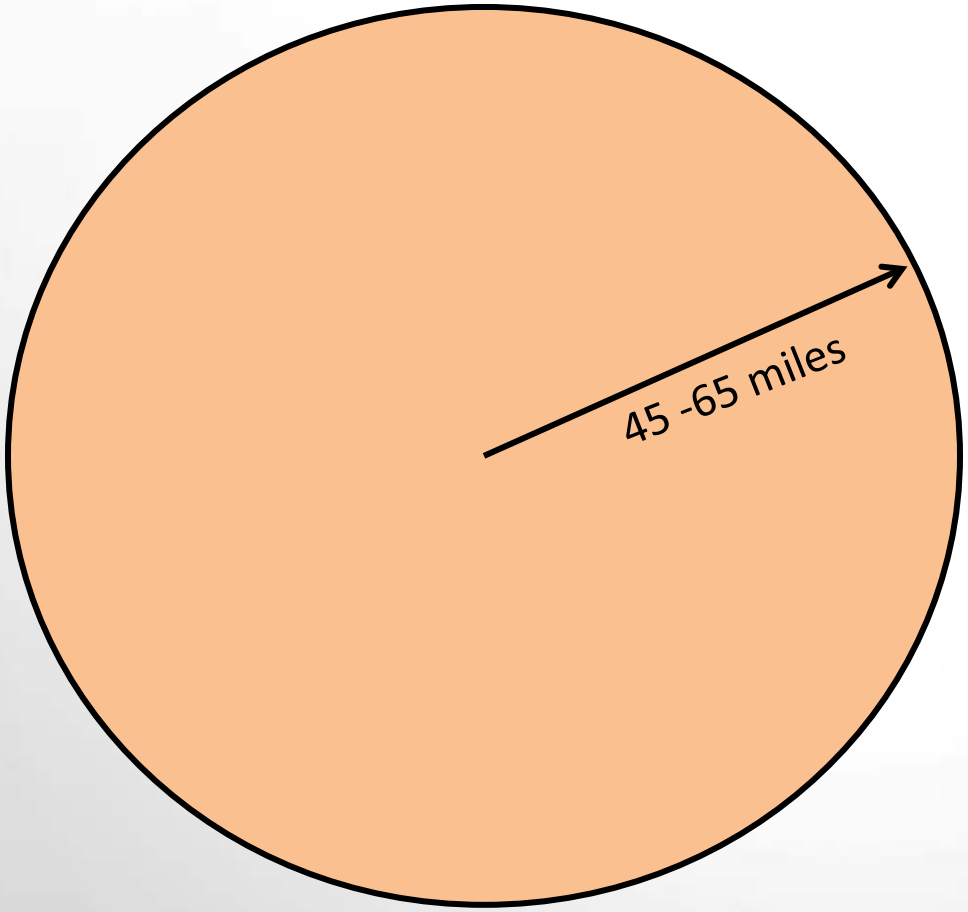
Part 1

BROADCAST SERVICE 101

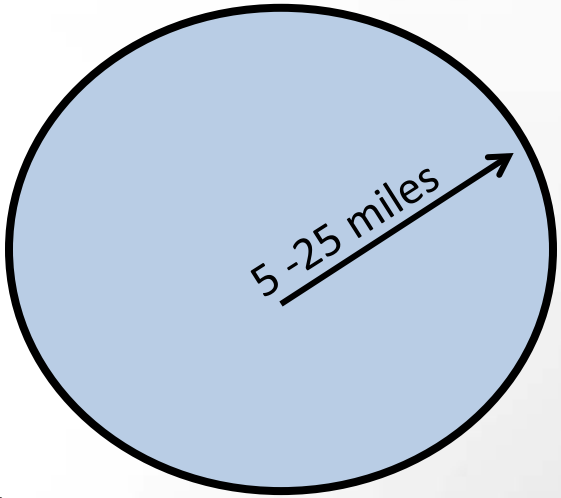
Broadcast Service

- US is divided into 210 Television Markets
- Two classes of television stations operate in US. Full Power Service and Low Power stations
- A Full Power Service stations usually covers a city or metropolitan market. A Low Power station covers smaller communities and are sometimes used to extend the reach of a larger metropolitan area
- Two classes of Low Power stations operate in US. Class A and Low Power/Translator stations

Coverage of Broadcast TV Stations



Full Power Service



Class A

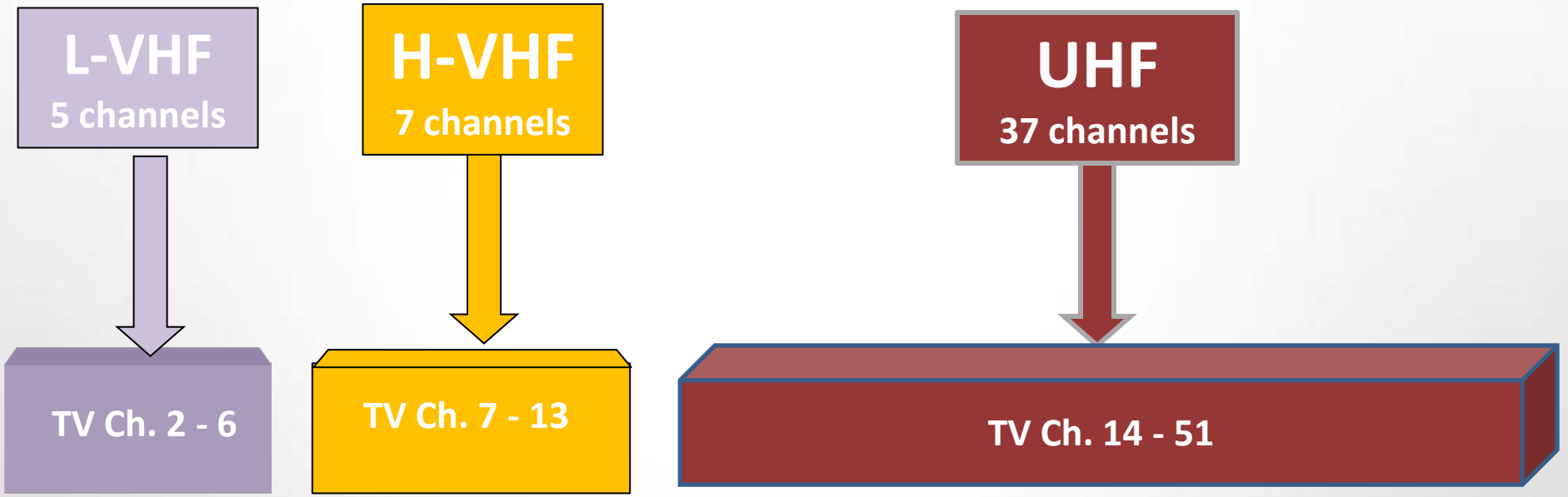
- Minimum amount of original programing
- Some interference rights

LPTV/Translators

- Fill-in and extension of full power service in rural areas
- Can be displaced by Full power stations

Full Power Service Stations

(Continental US)



40
TV stations

442
TV stations

1,273
TV stations

Total: 1,755 TV Stations

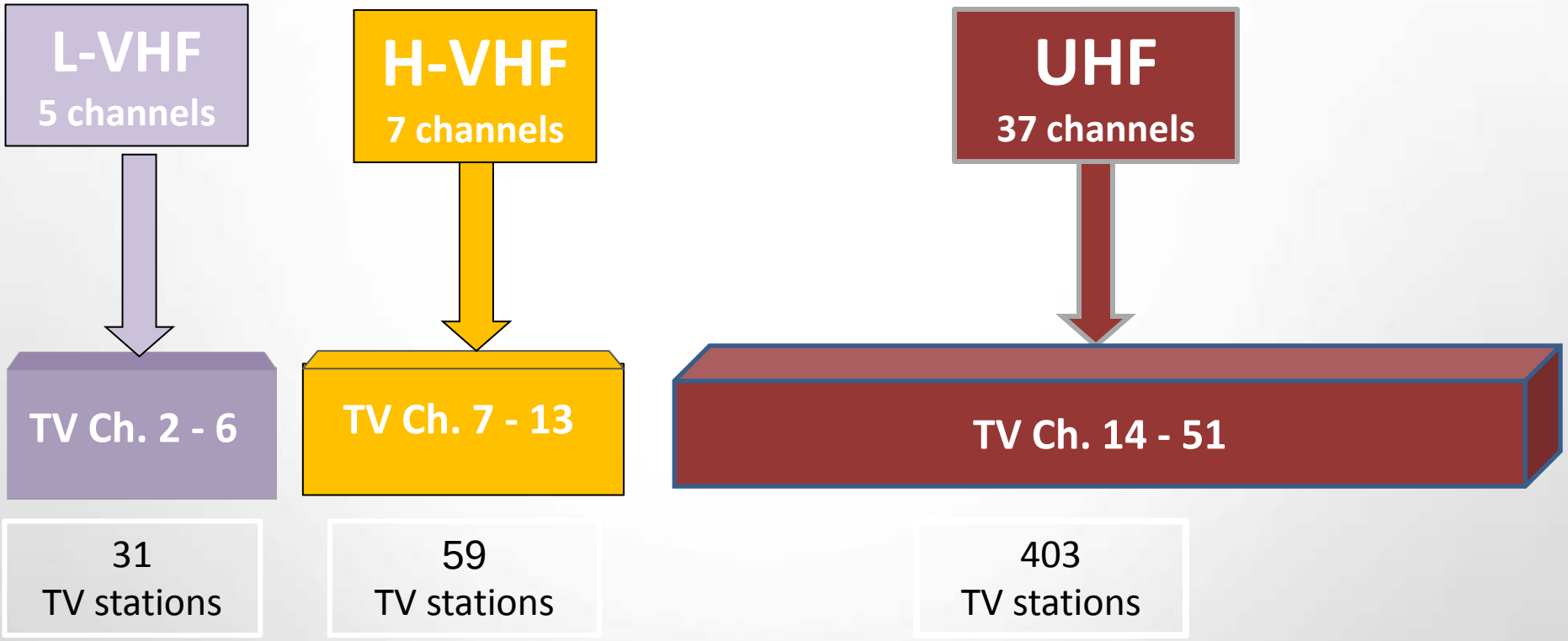
Distribution of Full Power Stations by Affiliation

Affiliation	Percent of Total
PBS	17.5
ABC (incl. O&O)	13.7
NBC (incl. O&O)	13.5
CBS (incl. O&O)	13.2
FOX (incl. O&O)	11.4
Independent	8.8
CW	5.6

Affiliation	Percent of Total
My Network	3.8
ION	3.7
Univision	2.9
Trinity	2.0
ETV	1.5
Telemundo	1.3
Telefutura	1.1

Class A TV Stations

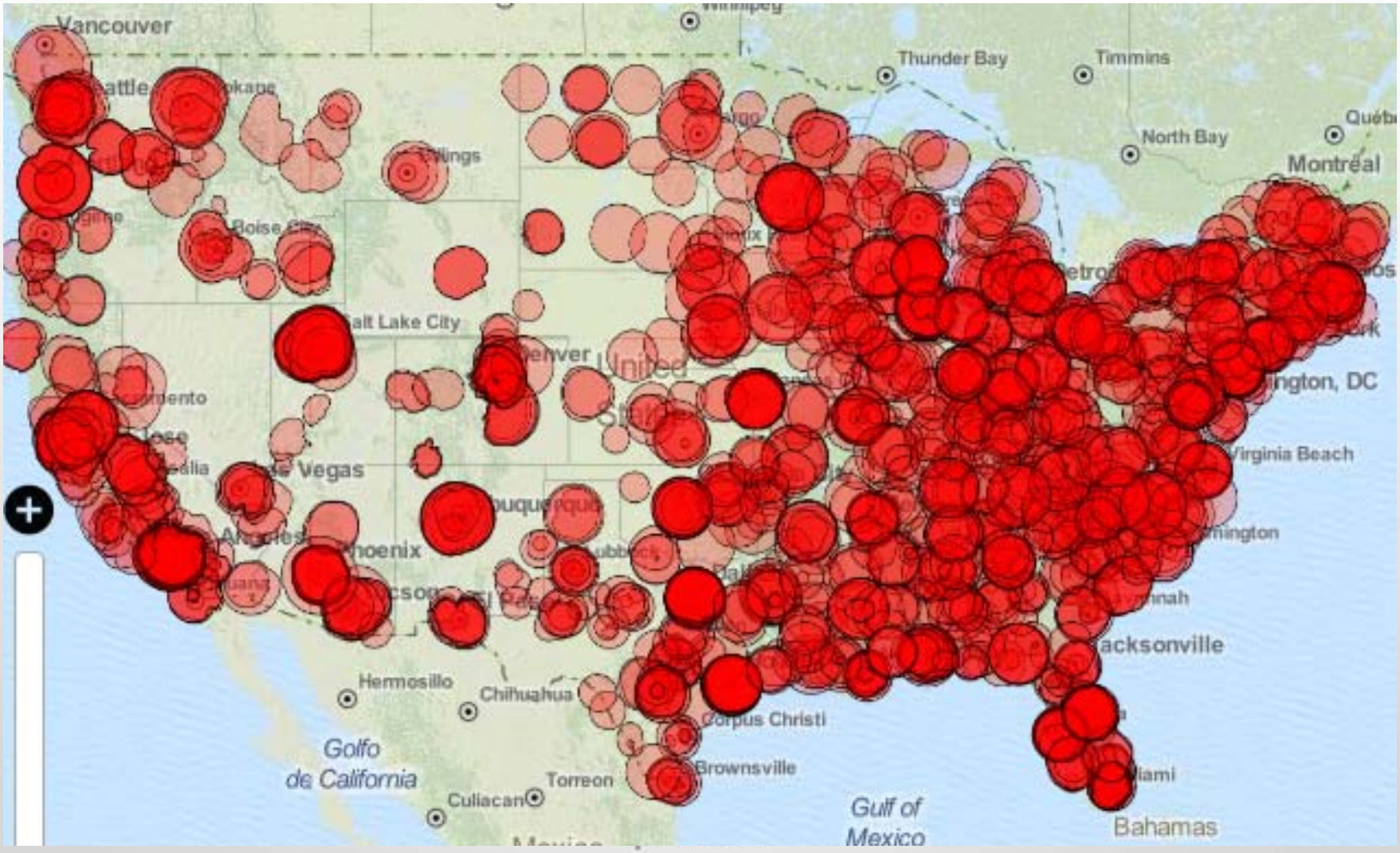
(Continental US)



Total: 502 Class A TV Stations

Distribution of Full Service + Class A

(UHF only)



Part 2

REPACKING MODELS - PAST AND PRESENT

Analog to Digital Conversion

(1994-1998)

- Goal: Find a new TV digital channel for every full service television station in the US. Replicate the analog coverage for the new channel, and minimize the number of channels assigned on TV Ch. 52-69 (currently identified as 700 MHz band)

- Develop two separate computer models – *an* ***Assignment model*** *and a* ***Coverage and interference (CIM)*** *model*, to determine the best selection of channels to accommodate and replicate all full service stations. The output from the CIM model results are fed into the Assignment Model

Analog to Digital Conversion

(1994-1998)

- **Assignment Mode**l included two modules. A constraint generator module that determines for each station all possible available channels given a set of user selected constraints, and the optimizer/evaluator module that uses a number of mathematical algorithms to iteratively search for the lowest number of channels that could be assigned
- A number of optimization techniques were investigated:
  - Successive augmentation algorithms. They solve problems by ranking TV stations based on a specified order of difficulties. Examples: (*Largest First(LF) by Welsh, Smallest Last (SL) by Matula, DSATUR (degree of saturation) by Brelaz, Recursive Largest First (RLF) by Leighton, and an iterative algorithm by Frank Box*
  - General algorithms that start with a random solution and propose small changes to the solution to improve the outcome. Improvements are determined by a set of penalty functions identified by the user (*Simulating Annealing by Johns, Neural network*). Other predictive algorithms such a Lagrangian Relaxation, and Graph Coloring algorithms were also investigated

Analog to Digital Conversion

(1994-1998)

- Simulated Annealing algorithm was determined to be the best algorithm for assigning digital channels, because of its cost/penalty function features that were used extensively to optimize a solution that limited the number of digital assignments between ch. 52-69
- The **Coverage and Interference module** was designed to feed the **Assignment Model** and furnish the interference results (cost/penalty information)

Digital Transition

(2004-2007)

- Goal: Find a new channel approximately 200 digital stations that were originally assigned on TV channel 52-69 below channel 52. Replicate the digital coverage on the new channel

- *Used the same **Assignment model** and a **Coverage and interference (CIM)** model*, to determine the best channel accommodation results, including the service area expected

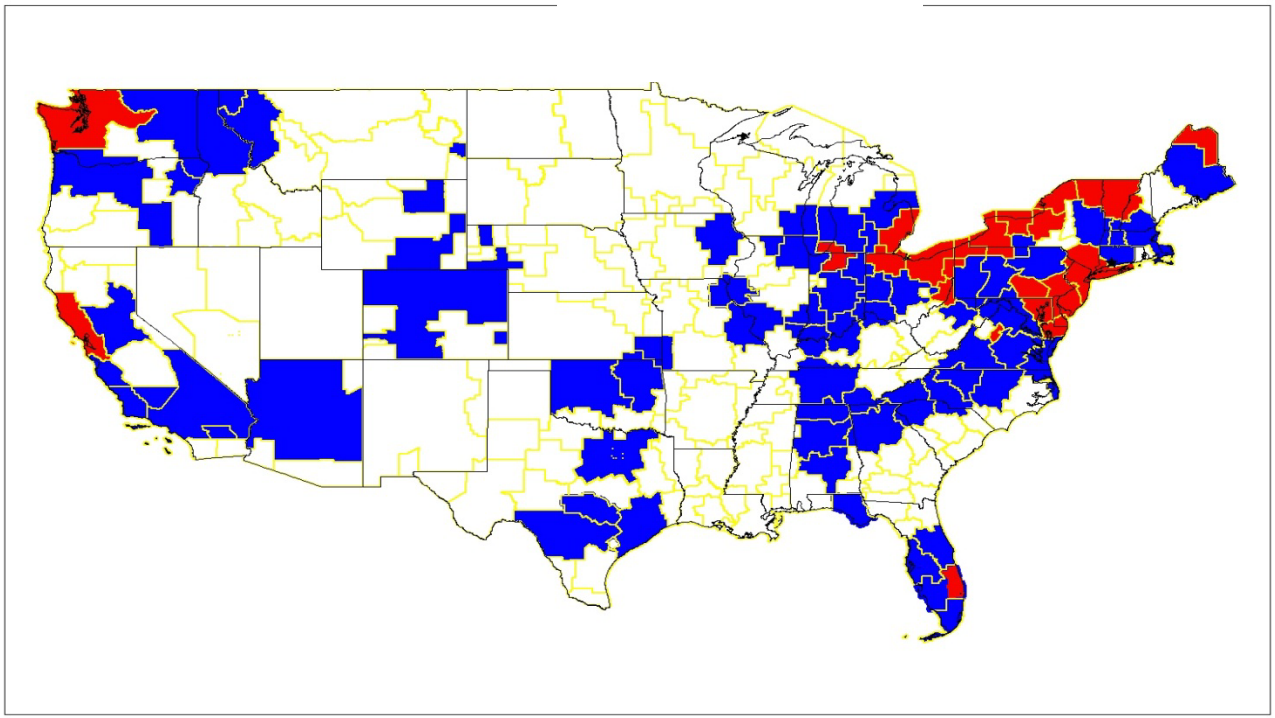
NAB Spectrum Repacking Studies
(2010/2011)

- Number of spectrum studies conducted using the same optimization algorithms
  - Studies looked at best case of reclaiming different amounts of spectrum (60, 84, 120 MHz) to assess impact
  - Studies considered full power DTV stations only, full power and Class A stations and all TV stations including LPTV/translators
- Study results:
  - Not all DMAs are impacted the same
    - Spectrum can be recovered many DMAs through repacking

DMA Industry Study Results

Amount of UHF Spectrum Reclaimed	Station Type	Minimum Number of Volunteers Needed	Number of DMAs Affected
120 MHz	Full Power + Class A	391	86
84 MHz	Full Power + Class A	215	53
60 MHz	Full Power + Class A	151	33

DMAs Affected by Reclaiming 120 MHz

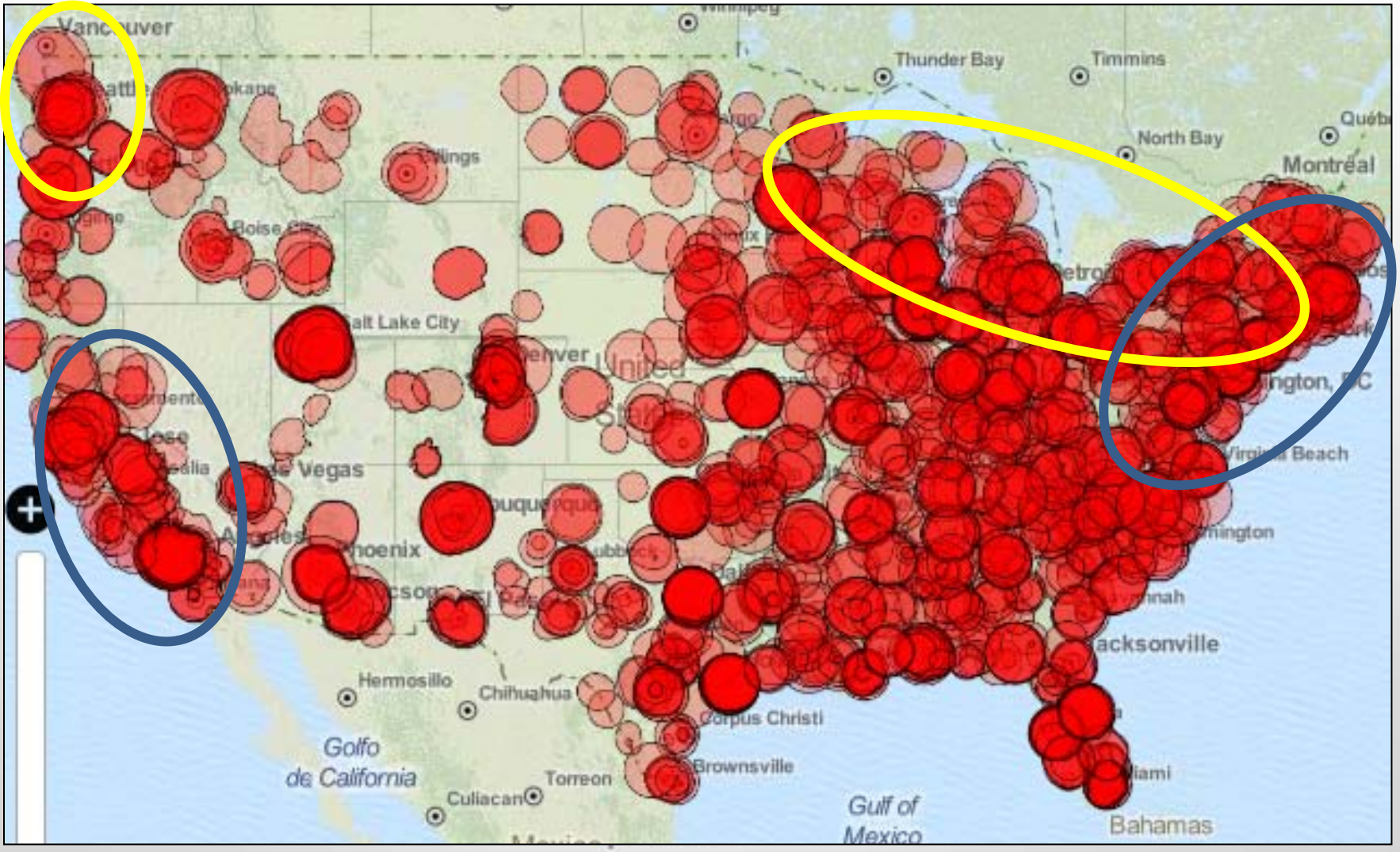


Station Shortfall for 120 MHz

(Full Power , Class A, Border Protection)

DMA Rank (2010-2011)	Market	Number of Stations	Stations With No Channel
1	New York	27	16
2	Los Angeles	29	14
3	Chicago	22	6
4	Philadelphia	24	14
5	Dallas-Ft. Worth	20	2
6	San Francisco-Oakland-San Jose	28	14
7	Boston	23	9
8	Atlanta	18	2
9	Washington, DC	22	9
10	Houston	19	4

Areas Most Seriously Affected by Repacking



Findings/Lessons Learned

- A limited number of DMAs are critical to the recovery of any amount of spectrum. Not all these DMAs are located in the top 30 markets
  - Relative location of these DMAs to each others are more important than their size. For example Salisbury, MD (DMA 143) and Scranton, PA (DMA 54) affect the repacking and recovery of spectrum in the Boston/Washington corridor
- The key to reclaiming any significant amount of spectrum depends on the collective decisions that will be made by all the stations that are within the DMAs in geographic areas identified earlier. Involvement/participation of all the stations is essential to repacking and the reclaiming any significant amount spectrum

Findings/Lessons Learned

- Canadian decisions regarding the disposition of the FCC spectrum reclamation proposal will have a great impact on the ultimate amount of spectrum being reclaimed in the US

- Repacking efforts should concentrate on these geographic areas. Need to determine *a priori* how much flexibility and elasticity exits to swap stations and channels within or between these DMAs (Biased repacking)

Part 3

Incentive Auction and FCC Process

FCC Process

- Fragmented FCC Process
  - Too much emphasis on Incentive Auction economics and mechanics, especially trying to solve the reverse auction holdouts
  - Limited consideration/appreciation of the value of the spectrum being auctioned
  - Current proposals ignored or deferred technical and regulatory issues or constraints that are critical to the success of recovering spectrum

FCC Process

- Limited consideration/appreciation of the actual value of the spectrum being auctioned
  - Wireless industry
    - Need a minimum amount of spectrum (72 MHz or more) on a national basis or in large congested markets such as Boston/Washington corridor to develop a new band. Fragmentation in the amount of spectrum in these congested markets would yield lower spectrum value. (Auctioning of the A block at 700 MHz)
  - Broadcast industry
    - Broadcast industry is well informed about the markets that have to volunteer their spectrum and the impact of the repacking will affect their business and future opportunities

FCC Process

- Current proposals ignored or deferred technical interference and regulatory issues that are critical to the success of conducting the auction
- A few examples:
  - Potential interference with a variable band plan
  - Canadian coordination

FCC Proposed Variable Band Plan

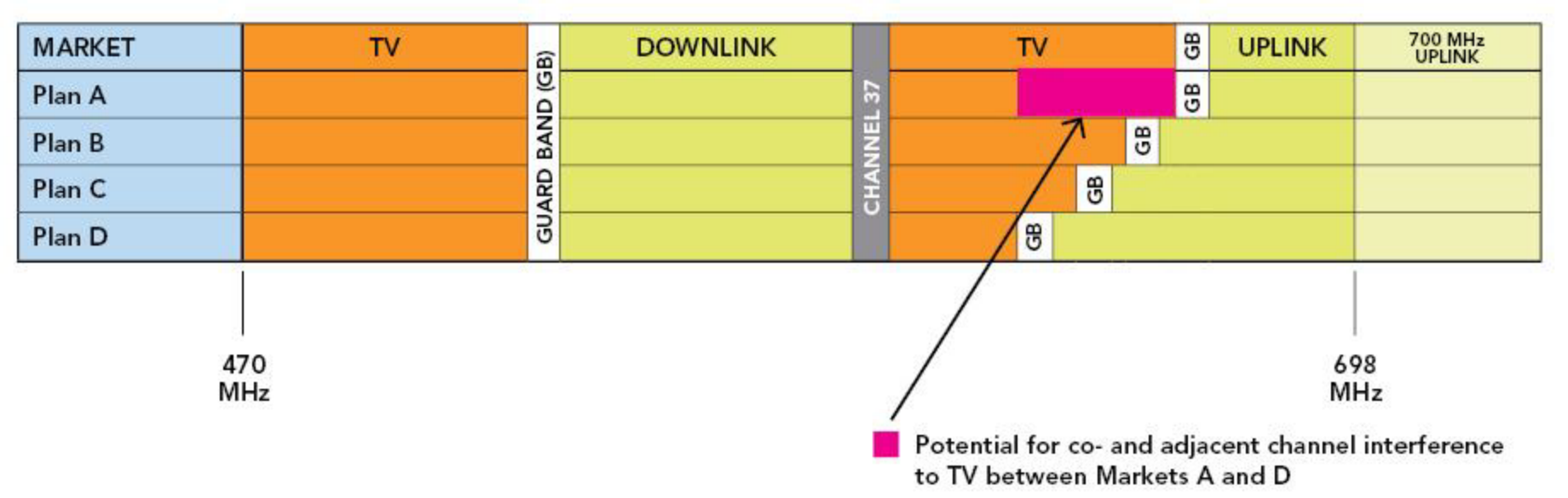
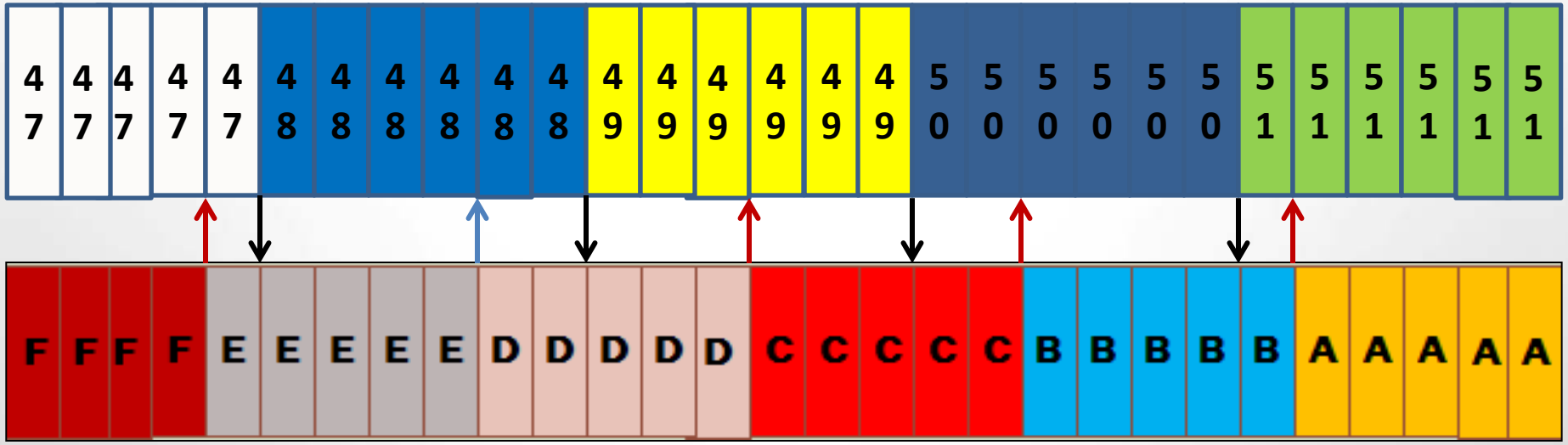


Illustration of Band Plan misalignment

TV Channels in 1 MHz increment



Wireless 5 MHz blocks in 1 MHz increment

Impact of Co and Adjacent Channel Interference

- Interference caused by allocating 5MHz wireless blocks in the same spectrum as 6 MHz TV channel allocation (i.e. variable plan) will result in more than one TV station or 5 MHz wireless block being affected
  - TV operation on a single channel **will cause co-channel interference on two contiguous 5 MHz wireless blocks**
  - Except for the first wireless block assigned next to Channel 52 A Block, a single 5 MHz wireless block operation **will cause co-channel interference to two TV contiguous channels**
  - Adjacent channel interference has similar impact for television and wireless

Illustration of interference from TV transmission on Wireless

- *TV operation on ch. 49 is co-channel to C and D blocks and adjacent to E and B blocks*

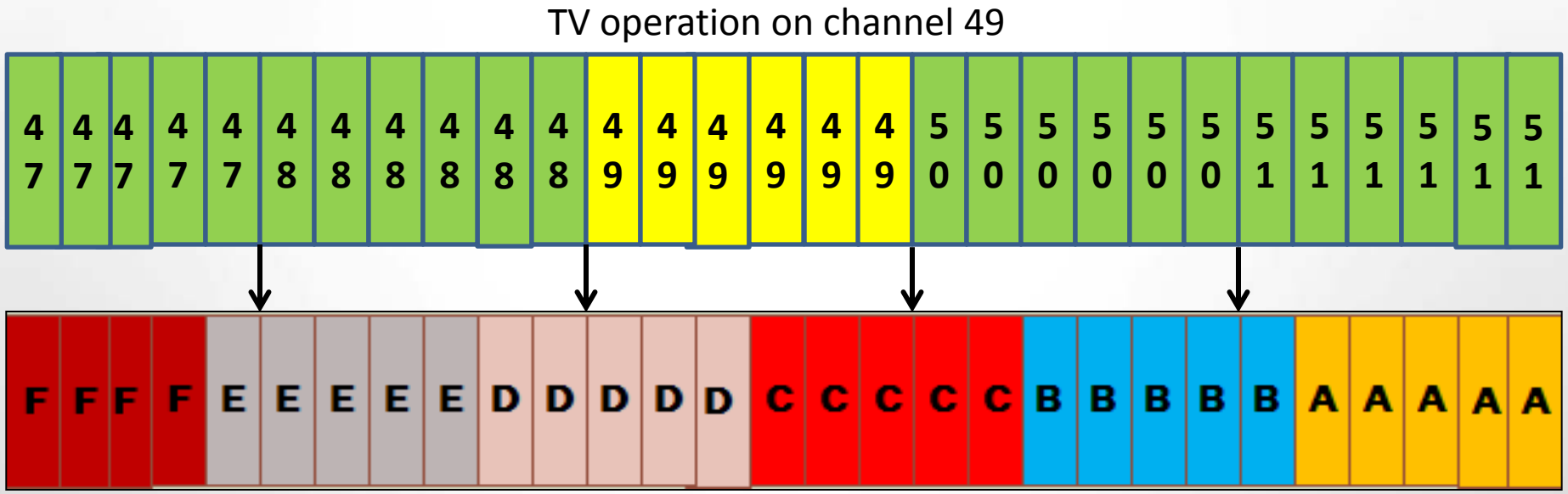
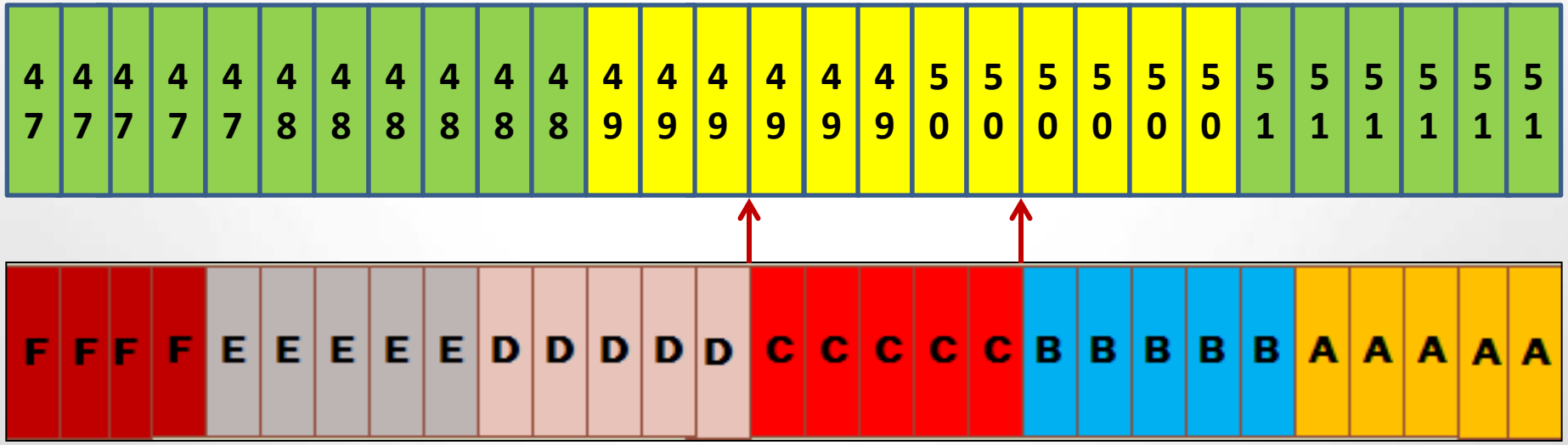


Illustration of interference from wireless transmission on TV

- C block operation will be co-channel to TV ch. 49 & 50



Transmission of C block

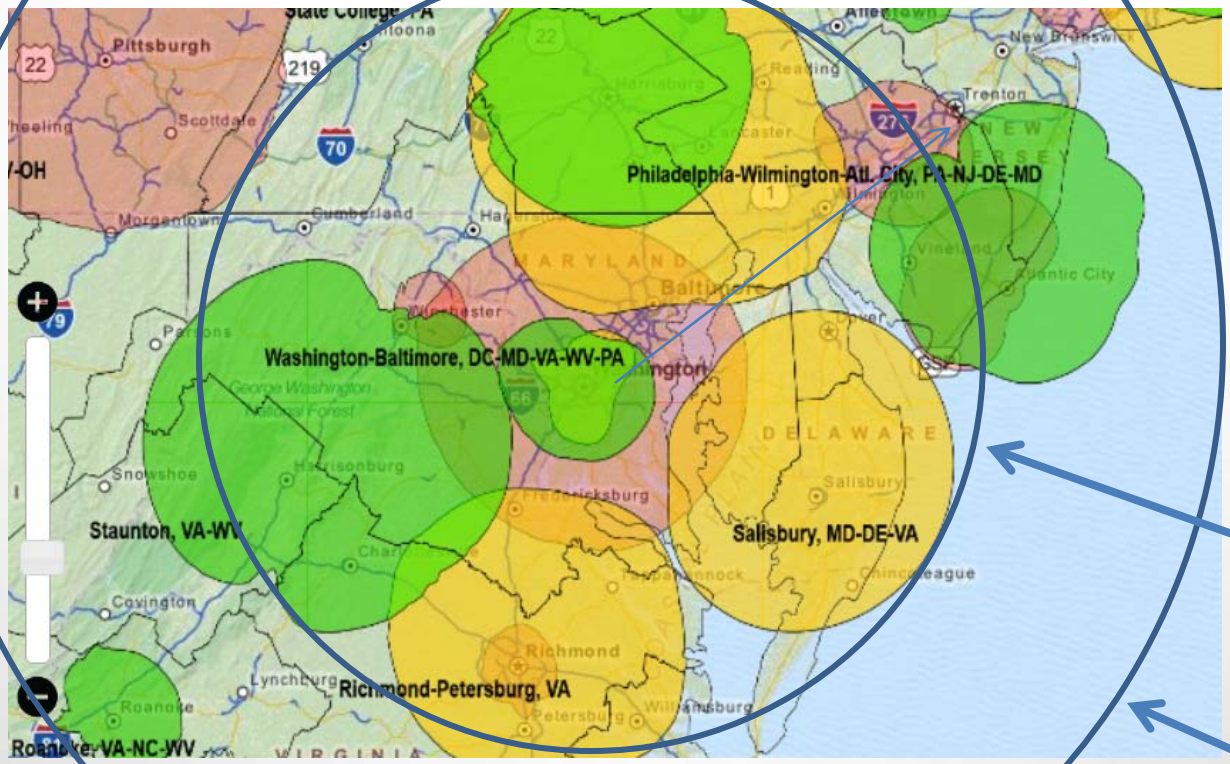
Inefficiencies of Variable Plan

- Require large separation distances/preclusion zones to share the same or adjacent channel or 5 MHz block
- Operation of a TV channel in the uplink band cause interference to four contiguous 5 MHz, requiring large separation distances
- Assigning 5 MHz blocks by Economic Areas (EAs) will further complete the process and add to the inefficiencies of repurposing spectrum
  - To illustrate the complexity/inefficiencies, we plotted the coverage of all full power and Class A stations in the Eastern Half of the United States that are operating on TV channels 47, 48, 49, 50 & 51 and overlaid the EAs boundaries.

Mitigate Co- and Adjacent Channels Interference

Operation	Interference		Separation Distance to Mitigate Interference (km)	
	From	To	Co-channel	Adjacent Channel
Uplink	Handset Transmission	DTV Receiver	DTV Contour + 5 km	DTV Contour
	DTV Transmission	Base station Receiver	225 to 375 km	100 to 130 km
Downlink	Base station Transmission	DTV Receiver	150 to 225 km	90 to130 km
	DTV Transmission	Handset Receiver	130 to 150 km	90 to 130 km

Uplink Separation Distances



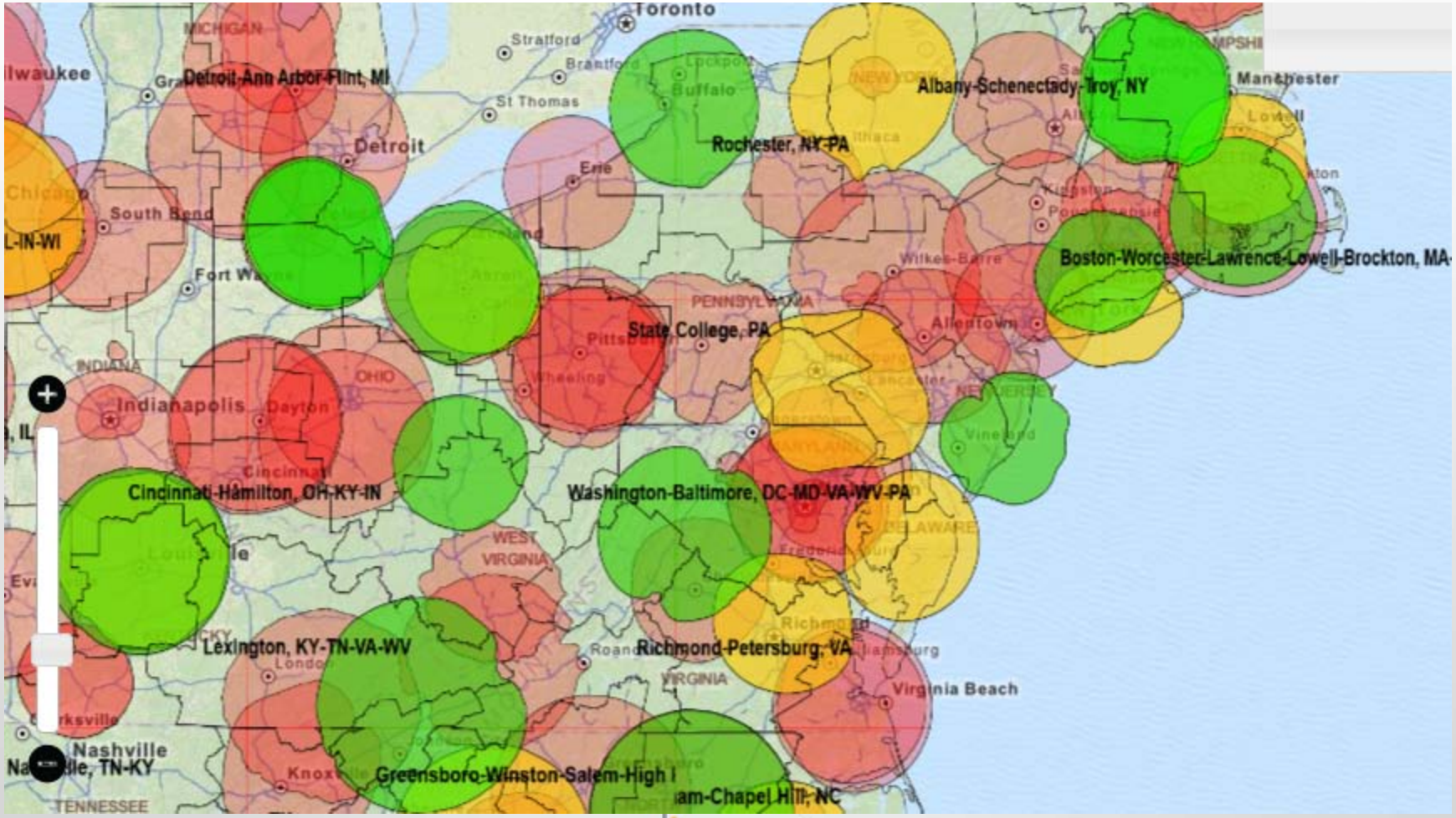
225 km

370 km

Washington-Baltimore EA
TV Channels 47, 48 and 49

NAB

Overlay of EA map Boundaries on TV channels 47,48,49,50,51 coverage



Part 4

Final Thoughts

Final Thoughts

- Current auction process is extremely complicated and focus on micromanaging the reverse auction and the speed of repacking
- More attention is needed to address the technical constraints that actually affect repacking and recovery of spectrum such as Canadian coordination, the inefficiency of a variable plan and the auctioning of the recovered spectrum using Economic Areas, etc.